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STATISTICAL STUDIES IN IMMUNITY.

A DISCUSSION OF THE MEANS OF ESTIMATING THE SEVERITY OF CASES OF ACUTE DISEASE.

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To the physician in the full practice of his profession there comes a considerable power of accurate prognosis. Of two persons apparently equally ill to the unpractised eye he is probably generally able to state which is likely to get better and which to die. This power exists most markedly among those whose practice largely consists of attendance on acute disease. The process by which the opinion is arrived at cannot be accurately described; it is largely subconscious. Due weight is given to a great number of symptoms and the favourable and unfavourable balanced against one another, but the conclusion is a personal opinion of the man himself. Were such a person's opinion taken as a criterion of the severity of a disease, it would probably be as accurate as anything human can be. Unfortunately physicians with this power highly developed are not common, and for statistical purposes other criteria of the severity must be sought. A number suggest themselves at once, and those which are most useful are the following:—

(a) The length of illness; (b) the mean temperature; (c) the day on which stimulation is first found to be necessary; (d) the age of the patient; and (e) in the eruptive fevers, the amount of eruption.

Now while each of these except perhaps (d) might be taken *à priori* as a fair measure of severity, and while there is no doubt that each does sort out the cases of the disease in grades of severity, yet none of them provides a complete test. The real test of severity is the percentage mortality. This represents a fact subject only to the error of random selection, and provides a means of estimating the access of severity occasioned by an alteration in some other circumstance. The evidence for this will become apparent later on in this paper; in the meantime it will be shown that each criterion of severity, while sorting out the cases in degrees of severity as gauged by the death rates, does so quite independently of any other.

In the first place it is to be noted that, though infectious diseases in general increase in severity from youth to age, yet the date on which the disease ends is not altered but remains constant; in other words, if recovery is to take place it will take place in a person of sixty on the average at the same time as in a person of fifteen, although the percentage mortality varies enormously between these two extremes; that is to say, the forces which control the acquirement of immunity vary independently of the amount in which they are present. As an illustration of this a table (Table I.), already given in a previous paper*, is given here. It is to be noted that not only does recovery take place at the same date in the illness, but that the date of death is also sensibly constant. Likewise in the same disease it may be shown that the weakening of the body brought about by the fever varies independently of the age and of the capacity of acquiring immunity. The day on which cardiac weakening first becomes apparent

TABLE I.
Cases of Typhus Fever. Dr Russell's Cases.†
Age Period, Crisis, and Death.

Day of Crisis or Death	0—14		15—19		20—30		30—40		40—50		50—	
	Recoveries	Deaths	R	D	R	D	R	D	R	D	R	D
7	—	—	—	—	—	—	—	—	—	1	—	1
8	—	—	—	—	—	—	—	1	—	—	—	2
9	3	—	2	—	2	—	—	2	—	1	1	3
10	3	1	7	1	7	—	7	2	4	5	1	3
11	3	—	16	2	11	6	3	2	11	1	1	1
12	7	1	12	—	23	1	15	2	4	5	4	2
13	7	—	23	2	19	—	13	1	6	2	3	2
14	2	—	11	1	21	—	17	5	7	2	8	4
15	5	—	7	2	7	4	2	3	3	4	—	1
16	—	—	—	2	2	4	—	2	1	2	1	—
17	—	—	1	1	—	2	—	1	—	1	—	—
18	—	—	—	1	—	2	—	3	—	1	—	2
19	—	—	—	—	—	—	—	—	—	1	—	—
20	—	—	—	—	—	1	—	—	1	—	—	—
21	—	—	—	1	—	1	—	1	—	2	—	—
22	—	—	—	2	—	5	—	—	—	1	—	1
Totals ...	30	2	79	15	92	26	57	25	37	29	19	22
Mean Day Recoveries	12·2	—	12·4	—	12·6	—	12·6	—	12·5	—	12·9	—
Deaths ...	—	11	—	15·6	—	16·2	—	13·7	—	13·8	—	12·2
Mean Day of Death of those dying under 20 days	—	11	—	14·1	—	14·3	—	13·5	—	13·0	—	11·8

* "Statistical Studies in Immunity. The Incubation Period and the Crisis." *Royal Philosophical Society of Glasgow*, 1906, pp. 17, 18.

† *Glasgow Med. Journal*, 1871.

is measured fairly accurately by the date on which stimulation is first found to be necessary. It is found (Table II.) that this also varies around a mean of singular constancy whether the patient is destined to recover or destined to die; in other words, the resistance of the body to the toxins of the fever as estimated by cardiac weakening is independent both of the age of the patient and of the amount of inherent capacity of acquiring immunity possessed by the patient: the former is shown by the independence of the mean day of stimulation on the age of the patient from youth to old age, and the latter on the independence of the day of stimulation at the same ages whether the issue be recovery or death. Evidence of the same independence of the day of crisis or death on the age of the patient in pneumonia and relapsing fever is given in the paper already cited.

× With regard to the temperature and the length of the illness, these also may be shown to be independent of each other. Table III. gives a correlation table for the cases of typhus fever admitted to Belvidere during the last six years. It will be seen again that, considering the number of cases, there is little variation in the mean date of crisis whether the mean temperature of

TABLE II.

Cases of Typhus Fever.

Age Period. Day on which first stimulated.

Day on which first stimulated	0—14		15—19		20—30		30—40		40—50		50—	
	Recoveries	Deaths	R	D	R	D	R	D	R	D	R	D
5	2	—	1	1	—	—	—	—	1	—	—	1
6	2	—	—	—	—	—	3	1	1	2	1	4
7	3	—	6	2	8	1	4	4	2	2	1	2
8	7	—	17	3	7	6	10	5	3	7	4	4
9	8	—	18	4	19	5	11	4	9	5	4	4
10	4	2	14	2	21	7	13	4	9	6	5	4
11	6	—	7	1	16	1	8	3	1	2	3	1
12	2	—	5	1	9	4	10	2	1	2	—	1
13	6	—	2	1	3	—	3	—	5	—	2	—
14	3	—	4	—	3	—	—	1	1	2	—	—
15	1	—	2	—	—	—	1	—	1	—	—	—
16	—	—	—	—	1	—	—	1	1	—	—	1
17	—	—	1	—	1	1	—	—	—	—	—	—
18	—	—	—	—	—	—	—	—	—	—	—	—
19	—	—	—	—	—	—	—	—	—	—	—	—
20	—	—	—	—	—	—	—	—	—	—	—	—
21	—	—	1	—	—	1	—	—	—	1	—	—
Totals ...	44	2	78	15	88	26	63	25	35	29	20	22
Mean Day of } Stimulation }												
Recoveries ...	9.9	—	9.8	—	10.2	—	9.8	—	10.1	—	9.5	—
Deaths ...	—	10.0	—	9.0	—	10.3	—	9.5	—	9.8	—	9.5

TABLE III.
Table showing the Correlation in Cases and Deaths in Typhus Fever between the Mean Temperature and Length of Illness.

Mean Temperature	100		100.5		101		101.5		102		102.5		103		103.5		104		104.5		105	
	Recoveries	Deaths	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D
7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—
8	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Totals	1	—	—	—	2	—	—	—	6	1	8	2	18	5	13	4	21	6	6	3	—	1
Mean Recoveries	12	—	—	—	12.5	—	—	—	15.1	—	14	—	14.3	—	16	—	15.4	—	15.0	—	—	—

For Recoveries $r = .11$.

Day of Illness or Death.

the fever is 101° or 104° . If the correlation be worked out by the ordinary product method, it is found to amount to .11 with a probable error of about the same.

A similar table is given (Table IV.) for the cases of Broncho-Pneumonia following Measles, showing the relation between the mean temperature of the disease and its duration. The correlation found by the product method is .04, again a negligible quantity. It is to be noted here also that the mean duration of the disease has no relationship to the average temperature. The same figures are redistributed for age and temperature (Table V.), and it is to be noted that the mean temperature is again independent of age. Likewise, when the correlation between age and length of illness is worked out, it is found to equal only .11. We have thus seen so far that all the different factors which are concerned in the processes of the reaction of the human body to the stimulus of fevers are affected independently by this stimulus, and although greater length of illness is associated with progressively greater severity, although the earlier the day of stimulation the greater the severity, and also the higher the temperature the greater the severity, yet all these sort out the severe and mild cases each in a manner quite independent of the other.

Hitherto, in estimating the relationship of measures of severity, it has not been shown that the characters represented are capable of quantitative measurement. Their relationship to the only criterion of severity, namely, the number of deaths in a given number of cases, may be investigated as follows. For comparative purposes it is necessary to have some standard method of measuring severity even when this is estimated by the number of deaths, for on the method by which this is done depends the results of the comparison. Severity might be taken as a linear function of the percentage mortality. This is, however, open to several objections. There does not seem to be any *à priori* reason why any disease which can kill should occur in a degree of mildness at which it is unable to kill at all, or that the severity should be so great that all attacked die. At any rate, the superior and inferior limits must be so far from the mean that for all practical purposes the curve of relationship may be presumed to possess asymptotes. Again, if the degree of severity is chosen so that each unit denotes a rise in the percentage mortality equivalent to the multiplication of each preceding value by a constant, the equation to the curve will be $y = ar^x$. Here the negative branch of the curve is asymptotic to the axis of x , but in the other direction the percentage mortality becomes infinite and it becomes possible for a disease to possess such severity as to kill any one affected many times over. This want of limitation at one end makes the application somewhat difficult*. I think that the best unit would be based either

* The reason why an organism is not presumed to possess a potential mortality of 200 per cent. is based on the results of experimental inoculation. When a large number of animals are inoculated even with the most virulent cultures of plague a certain proportion generally escape. Of course if very large amounts of the cultures are injected this may not hold, but such a condition is not comparable with any process of natural infection.

TABLE IV.
Correlation Table showing the number of Cases and Deaths with the Length of Illness and Mean Temperature in Cases of Measles with Broncho-Pneumonia.

Mean Temperature	99·5		100		100·5		101		101·5		102		102·5		103		103·5		104		104·5	
	Recoveries	Deaths	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D
0—5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5—10	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10—15	2	—	3	1	1	1	1	1	4	1	3	2	2	1	4	1	1	1	1	1	—	—
15—20	1	—	—	—	4	—	11	—	4	—	5	4	3	5	1	—	1	1	—	—	—	—
20—25	—	—	—	—	1	—	1	—	1	—	4	1	—	1	—	—	—	—	—	—	—	—
25—30	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30—35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
35—40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
40—45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mean Recoveries	12·5		17·5		15·8		15·5		14·5		18·5		15·5		16·2		17·5		12·5		—	

For Recoveries $r = \cdot 04$.

TABLE V.

Table showing the relation of Mean Temperature of Disease to Age in Cases of Measles with Broncho-Pneumonia.

Mean Temperature.	Age in Years		-1		1		2		3		4		5		6		7	
	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D
104.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
104	1	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—
103.5	—	2	—	—	1	—	—	—	—	—	1	—	—	—	1	—	—	—
103	—	1	—	—	2	—	3	1	—	—	1	—	—	—	—	—	—	—
102.5	1	—	—	—	6	1	1	1	2	—	1	1	—	—	—	—	—	—
102	1	3	5	2	5	4	1	1	—	2	—	—	—	—	1	—	—	—
101.5	—	1	2	1	3	1	1	—	—	5	1	—	1	2	—	—	—	—
101	3	—	4	—	3	1	5	—	—	—	—	1	1	1	—	3	—	—
100.5	1	1	3	—	3	—	1	—	1	—	—	—	—	1	—	—	—	—
100	—	—	—	—	1	—	—	2	—	1	—	—	—	1	—	—	—	—
99.5	—	—	—	—	—	—	—	3	—	1	—	—	—	—	—	—	—	—
Totals	7	8	14	15	15	11	15	3	11	2	2	2	7	—	3	—	—	—
Mean Recoveries	101.7		101.3		101.4		100.7		101.1		101.7		101.3		101.0			

For Recoveries $r = .03$.

on correlation or association. If a series of deaths and recoveries arranged in gradation of severity be taken and denoted as d_1, d_2, d_3, d_4 and r_1, r_2, r_3, r_4 , etc., then if $c \left| \begin{smallmatrix} d_1 & d_2 \\ r_1 & r_2 \end{smallmatrix} \right| = c \left| \begin{smallmatrix} d_2 & d_3 \\ r_2 & r_3 \end{smallmatrix} \right| = c \left| \begin{smallmatrix} d_3 & d_4 \\ r_3 & r_4 \end{smallmatrix} \right| = \dots = p$ (a constant), where $c \left| \begin{smallmatrix} d_1 & d_2 \\ r_1 & r_2 \end{smallmatrix} \right|$

denotes the correlation coefficient of such a fourfold division, the unit of severity might be taken as proportional to p . The disadvantage of this is, that there is in general no way of obtaining for purposes of comparison the suitable values of r_1, r_2, r_3, r_4 and d_1, d_2, d_3, d_4 . The groups have usually been classified on some quite different basis. For purposes of working we are therefore thrown back on

a coefficient of association such as that proposed by Yule, namely, $\frac{ad - bc}{ad + bc}$, or

in the improved form as given by Prof. Pearson, namely, $\sin \frac{\pi \sqrt{ad - bc}}{2 \sqrt{ad + bc}}$. The

value of the latter is approximately equal to the value of the correlation coefficient. If the deaths be denoted by unity in two succeeding classes and the recoveries by r^n and r^{n+1} , a fourfold division $\frac{1}{r^n} \left| \begin{smallmatrix} 1 & 1 \\ r^n & r^{n+1} \end{smallmatrix} \right|$ has a coefficient of association which is independent of n and only a function of r .

The curve of percentage mortality given by this association, where x denotes units of severity and y the percentage mortality (the axis of y being taken so

that when $x = 0$, $y = 50$ per cent. and the branch of zero mortality asymptotic to the positive branch of the axis of x), is $y = \frac{100}{r^x + 1}$. This is at best but an approximation, but it is sufficient for the present purposes.

Such a formula allows us to determine the position along a base line of cases with a definite death-rate which have been grouped by some other criterion of severity. As a first example, comparison may now be made between the criterion and the day on which patients are first stimulated in typhus fever. The day on which stimulation is first found to be necessary in the course of this disease is a measure of the degree to which the patient's muscular or nervous equipment of the heart has been poisoned by the disease process. In this case and in all the subsequent examples the numbers are unfortunately small. To exclude error as far as possible, the numbers stimulated each day have been combined into two series in two day periods and the curve fitted to one of these alternate series by the method of least squares compared with the values of the mortality deduced from the other. It can be seen that the correspondence is very close, showing that a unit of time in the length of illness can be approximately represented by a unit of severity as given by the formula described. The manner in which the distribution fits the curve of severity is shown in Diagram I. both for the rough observations and for the

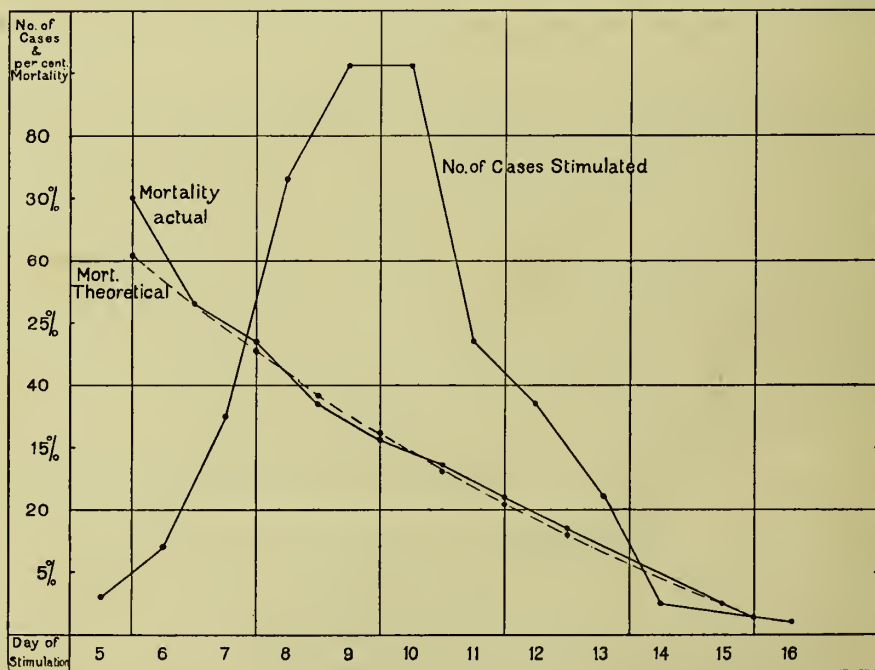


DIAGRAM I. Showing how the actual data from deaths and cases in typhus fever fit themselves to a criterion curve and showing that the day on which a patient is first stimulated corresponds closely to a unit of severity.

smooth curve. It might have been thought that it would have been better to have smoothed the curves of the numbers of cases and deaths first, then calculated the death rates from the smoothed results and fitted these values to the "criterion curve," but this is open to the objection that the cases of typhus are brought to the hospital for the most part after the sixth day of illness, and therefore the statistics of both the cases and deaths have smaller numbers at this early date than are correct. The distributions obtained from the figures consequently give values of the mortality probably subject to much greater error than the values deduced from the figures themselves. As a second example, it is also found that the percentage mortality increases with the mean temperature characterising the course of the febrile attack in the same manner. In both these instances it is to be observed that the range of the cases as given in days in the first instance and in average temperature in the second corresponds to only a small portion of the "criterion curve." There is in neither any indication that a mortality approaching the limits of zero or of 100 per cent. occurs at the ends of the range. The figures are unfortunately too small to permit of any absolute deductions, but the discrepancy between the theoretical and the actual values of the mortalities are not so great as to prevent the belief that length of illness and the average temperature in illness vary approximately in a linear fashion with the unit severity as measured by the abscissa of the "criterion curve."

In all the examples hitherto given, whether measured by length of illness, height of temperature, day of stimulation, or age, it is found that there is a frequency more common than any other on either side of which cases occur with less and less frequency. A considerable number of examples in addition to those given here have been collected in my paper already referred to and need not be repeated, but both in the instances published and in others collected but not published the same phenomenon is observed. I have come on no instance of a disease having its maximum or minimum severity corresponding to either the maximum or minimum frequency, though it is possible some such relationship exists in some disease not yet examined.

The only criterion of severity not hitherto considered is the amount of eruption. The disease in which this is most naturally applied is smallpox. Here, as has been seen in recent numbers of *Biometrika*, there is evidence that the mild cases in vaccinated subjects are so much the most common as to constitute a grouping of a kind quite different from that already found to be the rule when any other criterion has been taken, and indeed if the severity is to be taken as a linear function of the number of elements of eruption I think an exception exists. But in smallpox we are dealing with a disease caused by a parasite with a very complicated life-history, a disease in which the parasite elaborates two, and in all probability three, completely different sets of toxic or self-protective bodies, against which the human organism even in the unvaccinated state possesses very varied powers of resistance. These substances are:

(1) the poisons elaborated during the stage of the invasion of the disease: (2) a protective substance elaborated by the variolar organism (or possibly a lack of defensive powers on the part of the human organisms) during the stage when the organism is invading the skin; and (3) the toxic substances elaborated during the stage of development in the skin. Now against the first of these remote vaccination does not protect at all, but with regard to the second and third the resistive powers of the vaccinated subject are not often wholly lost. If the means of defence remain most perfect against the second stage, then cases with a small amount of eruption will necessarily be most frequent. But many of the cases with a sparse eruption run the full course of unmodified smallpox, although it is more general for the vaccinated organism to retain at a high level the protection against both the second and third stages in the growth of the variolar parasite. But in any case it is hardly proper to assume that the protection against the second stage is the sole criterion of severity in smallpox, or that even if it were a patient with 5000 pocks on his face is 5000 times as severely ill as one with one pock. The example of cases of smallpox in unvaccinated persons already treated by Prof. Pearson in *Biometrika* rather negatives this idea, especially when considered in relation to the "criterion curve." Here the cases can be classified by the character of the eruption for each class of which the death-rate is known. Fitting these values to the equation of the curve already found and assuming the value of r to be equal to 2 and that the mortality of the haemorrhagic cases is 98 per cent. (for at least two in one hundred recover in our experience), we find that the abscissae corresponding to the sparse, the abundant, the confluent, and the haemorrhagic cases to be respectively 3, 1.2732, -1.1443, -5.615. With so few divisions it is obviously hopeless to make an adequate attempt to fit a distribution to the figures, but we find for the moments $\nu_1 = -1.153$, $\mu_2 = 3.060$, $\mu_3 = -2.955$, $\mu_4 = 41.245$ and $\beta_1 = .3056$, $\beta_2 = 4.4053$ a distribution of Type IV. where the mean and commonest form is that corresponding to the type of cases with a confluent eruption (see Diagram II.). This is practically the same as has already been found by Prof. Pearson. It is thus evident, comparing this distribution with that given by the number of pocks, that as far as these can be surmised from Dr Turner's data (for I have no such data for comparison of my own), that by no means does a linear distribution of severity derived from a consideration of the number of pocks fit the criterion of severity as deduced from the death-rate. The whole sensible range of the distribution curve represents in fact only about sixteen units, of which half are devoted to those cases with a confluent or haemorrhagic eruption and half to those with an abundant or sparse eruption. In the same diagram are roughly sketched the similar distributions of those cases of smallpox in which vaccination was performed more than 45 years previously and between 25 to 45 years previously. In these cases the sparse are divided into sparse and very sparse, and while the latter cannot be placed on the base line from lack of accurate knowledge of its death-rate, it must be apparent that a moderately symmetrical curve could

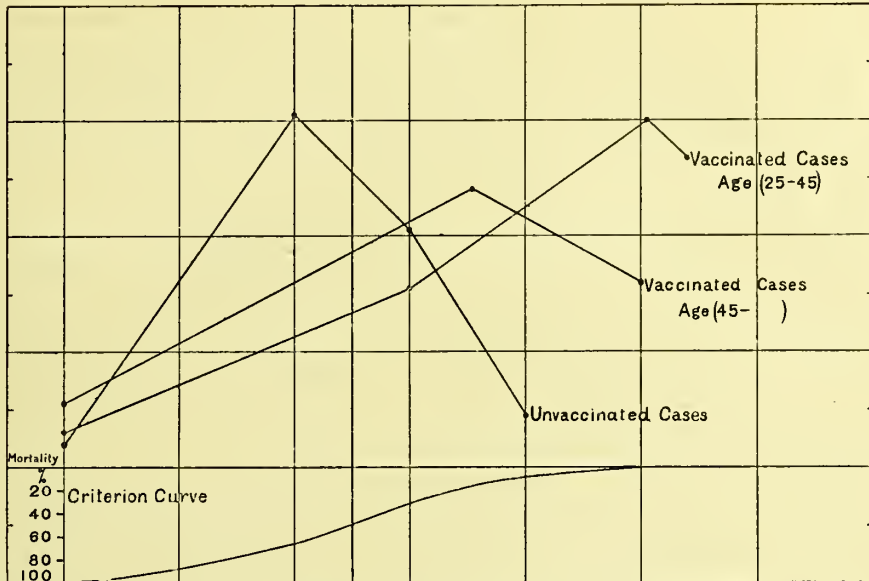


DIAGRAM II. Showing in a very rough manner the mode in which cases of smallpox occurring in specified classes group themselves when arranged according to their mortalities. The absence of regular scale is due to the fact that there is no real knowledge as to the length of abscissa which corresponds to each given ordinate and the fewness of groups makes the fitting of distributions almost impossible. The heavy vertical line represents $x=0$.

Table of the Figures on which above Diagram is based.

Number of Cases of Smallpox with Amount of Eruption and Corresponding Deaths in three Different Classes.

	Haemorrhagic		Confluent		Abundant		Sparse		Very Sparse	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Vaccinated 25-45 years before attack	29	29	155	49	299	8	267	5	182	—
Vaccinated more than 45 years before attack	11	11	35	21	48	9	32	1	29	—
Unvaccinated	4	4	61	42	41	12	Cases		Death	
			41	12	61	42	9		1	

To obtain the abscissa the death rate of each group was substituted for y in the equation $y = \frac{100}{2^x + 1}$ and an ordinate proportional to the number of cases erected at the point obtained. The scale in the diagram is different for each class and can easily be estimated from the figures themselves.

easily be devised to represent both groups. The maximum falling among the abundant cases where the higher ages are considered and on the borderland of the sparse and abundant cases where the middle ages are considered so that the maximum with increasing protection due to the nearness of vaccination passes to the right and the standard deviation increases. This concludes all that can be said at present concerning the amount of eruption as a criterion of severity except in one particular. It is to be noted again that the amount of eruption while sorting out the cases in grades of severity does so independently of the capacity of acquiring immunity if the group of sparse cases is considered as belonging to a special class, namely that in which the acquired immunity remains at a high level for both the severe and third stages of the disease. The following excerpt from my former paper with the accompanying table will show that, when the eruption is abundant or confluent, the development of acquired immunity proceeds quite independently of the amount of eruption.

"The date of the first bath was chosen as representing the end of the disease, and the cases showing an abundant or confluent eruption selected for comparison. A complication arises here as the presence of boils frequently delays the baths, and the larger the surface involved in the smallpox eruption the greater the likelihood of this secondary infection. A series of means has therefore been calculated representing the duration of the illness in all cases ending up to each definite date, and it will be seen that again there is a singular constancy in these means whether the cases be mild or severe, with the exception that there is a greater tail of septic cases among those with a confluent as compared with those with an abundant eruption.

"The general conclusions which are to be drawn from this series of facts is that for any given disease there is little difference in the method by which immunity is produced, or in the period at which the curative properties of the body come into action, even although the ability of the organism to produce the necessary anti-bodies varies immensely."

TABLE VI.

Table showing Number of Cases of Smallpox in Vaccinated Persons having the first bath on each day after onset of disease, with the corresponding Means.

Day of First Bath	Eruption		Mean Duration of all Cases up to the respective day	
	Abundant	Confluent	Abundant	Confluent
4	1	1	—	—
5	2	—	—	—
6	—	—	—	—
7	7	1	—	—
8	15	5	—	—
9	18	10	—	—
10	24	9	—	—
11	24	8	—	—
12	27	14	9·8	10·1
13	22	5	—	—
14	20	8	10·8	10·9
15	12	7	—	—
16	6	10	11·4	11·9
17	8	6	—	—
18	3	4	11·8	12·7
19	3	2	—	—
20—25	11	9	—	—
25—30	4	8	—	—
30—40	2	4	—	—
40—50	—	Total,	13·3	15·3
50—60	—	—	—	—

